ASSESSMENT OF POTENTIAL COAL-LIQUID MIXTURE FUEL UTILIZATION IN CANADA

SUBTASK: A.1, PARTS OF ITEMS 1.0 AND 2.0; ITEMS 3.0 and 4.0
SUBTASK: A.4 and A.5
TASK B

FINAL REPORT
BY
MONTREAL ENGINEERING COMPANY, LIMITED

MICROMEDIA

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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555 Booth Street
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Attention: Dr. H. Whaley

Gentlemen:

Assessment of Potential Coal-Liquid
Mixture Fuel Utilization in Canada
DSS File: 14SQ.234401-9080-1

Enclosed please find the final report on the subject study, covering:

Subtask A.1, Parts of Items 1.0 and 2.0;
Subtask A.1, Items 3.0 and 4.0;
Subtasks a.4 and A.5, and
Task B.

With a copy of this letter, we forward one copy each of the report to Dr. R. Thomson, CANMET and Dr. Maureen Brock, Science Procurement Centre.

We would like to take this opportunity to thank you and Dr. R. Thomson for the attention and support received throughout this study and to express our appreciation to Dr. M. Brock for her kind co-operation.

Yours very truly,

S. Detre
Manager, Thermal Study Group

SD/cr
Encl.
cc: Dr. M. Brock, DSS (Encl.)
Dr. R. Thomson, CANMET (Encl.)

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A.1 FUEL RESOURCES, TRANSPORTATION AND CLM PREPARATION PLANTS

1.0 COAL FOR CLM APPLICATIONS

1.7 Transportation from the Mining Site to the CLM Preparation Facility:

CWM preparation plants: installed at Sydney mine site (Cape Breton Development Corporation)
COM preparation plants: dedicated (Scotia Liquicoal) transportation by rail or barge

1.8 The Additional Coal Traffic Will:

CWM: N/A
COM: Probably will not exceed the existing transportation capacity

1.9 Estimated Coal Transportation Cost:

CWM: N/A (See Section 1.7 above)
COM: Rail: $15*/Tonne/1000 km
Barge: $7/Tonne

1.10 As-Received Coal at the CLM Preparation Plant:

CWM: Washed
COM: Washed

1.11 Estimate Cost As-Received Coal

$60/Tonne (1982, washed)

* All cost figures presented in this report are in mid-1982 Canadian dollars.

2.0 OIL FOR CLM APPLICATIONS

2.4 Transportation to the CLM Preparation Plant:

CWM: N/A (See Section 1.7 above)
COM: By rail tank car; barge; or tank truck

2.5 Estimated Oil Transportation Cost

By rail tank car; barge/tanker; or tank truck at an estimated cost of $1.58/bb in 1982 and a projected cost of $2.40/bb by 1986.

2.6 Estimate Cost of As Received Oil

$25.08/bb Alberta conventional old oil as received in Montreal in 1982 and $56.15/bb as received in 1986.

3.0 CLM PREPARATION PLANTS

3.1 Number of existing on-site (dedicated) CLM plants:

None

3.2 Number of existing centralized CLM preparation plants:

- COM: None

- CWM: None

- Others: COWM: Total Capacity: - 1 1/2 ton/hr current
  - 6 ton/hr rated

3.3 Potential future CLM preparation plants:

- COM: None

- CWM:- pilot plant at 4 ton/hr capacity by Cape Breton Development Corporation/ABCarbogel (CBDC/ABC) at Sydney, Nova Scotia, see section B.1 - Project No. 1, year of operation: 1982

  - Commercial plant at 200 ton/hr (centralized) by CBDC, year of operation 1985-86

- COWM: Commercial plant at 750,000 bbl/yr capacity (centralized) by Scotia Liquicoal (SLC), location: Nova Scotia, year of operation 1985-86

4.0 CLM TRANSPORTATION

Based on the National Energy Policy (NEP), it is anticipated that CLM could possibly replace oil to a substantial degree in the Atlantic Provinces only. It is also anticipated that the need for coal for this purpose could be entirely satisfied from existing and developing Nova Scotia mines - particularly Cape Breton mines. Centralized CLM plants are to be constructed at mine-sites thus eliminating the coal transportation problem. Transportation of oil to power plants and industrial users will thus be replaced by transportation of slurries. This would result in increased demand on present liquid-transportation infrastructure in a ratio 1.8:1 (assuming worst case, i.e., conversion entirely to 70/30 CWM). Assuming further that 10% of total energy would still be generated from oil (e.g. utility peaking), the above ratio would reduce to 1.6:1.

Current oil-fired generation capacity in the Atlantic Provinces adds up to about 1360 MWe representing oil consumption of about 1.7 million short tons/yr. The estimates do not include Coleson Cove's oil consumption due to plans for the conversion of this station to pulverized coal. However, the coal demand analyses carried out in Section 1.0 of Subtask A.1, include the Coleson Cove station as a potential for conversion to CLM. If all capacity is converted to CWM, increased load on liquid transportation system would be about 1 million short tons/yr. for a total of 2.7 million short tons/yr.

A.4 INSTITUTIONAL FACTORS

1.0 NATIONAL ENERGY POLICY

The rapidly rising cost of crude oil coupled with an insecurity of supply have caused the western industrialized nations to seek feasible alternatives for petroleum-based derivatives. For the past few years, Canadian industry has been sheltered from the direct impact of escalating oil prices by an oil subsidy program which resulted in the domestic cost of crude oil being about half of the world market price. This picture is now in process of change with the announcement of the November 1980 National Energy Program and recently negotiated oil-pricing agreements between the federal government and the major oil-producing provinces. As a result, the domestic price of crude oil is expected to progressively rise by more than four-fold over the next decade.

Recently, however, on the global scene, the combined effects of economic recession and conservation have resulted in a steady decline in oil consumption. It is anticipated that demand could continue to decline for at least another year or two. The current world oil price decline has brought new complications into energy policy in terms of uncertainty. Canada faces difficult challenges from the current international oil price situation; some energy developments will be sensible only if oil prices rise consistently in real terms, other are viable with more moderate oil price increases. Canada has, however, many energy options which are not inhibited by the current uncertainty - typically smaller-scale options - such as low capital cost conversions.

The role of coal in the Canadian economy is complex. The geography of Canada, variety of alternative energy options and projected requirement for coal for use as an adjunct fuel in the extraction and processing of the oil sands, are main influential factors. Coal currently meets about 11% of primary energy demand in Canada, two-thirds of which is used for electricity generation. Electricity is a key element of Canadian energy policy as an alternative to oil. In Atlantic Canada, where most electricity is generated by oil-firing, an Off-Oil Utility Fund of $175 million has been established. Under the National Energy Program, Special Atlantic Initiatives, the Department of Energy, Mines and Resources has undertaken to assist the utility companies of the Atlantic Provinces in the commercialization of CWM as a substitute for residual oil.

Another off-oil option in Canada is natural gas. Several initiatives are being undertaken by the Government of Canada to expand gas markets and to extend the gas pipeline to Quebec and the Maritimes. The current economic slowdown has also depressed gas export markets and thus slowed gas exploration efforts. The Government of Canada, however, remains determined to bring natural gas to the Maritimes from the West and at the same time support natural gas exploration at the Sable Island, off Newfoundland.

2.0 FUEL PRICE POLICY

It is Canadian Federal Government policy to maintain oil prices in Canada lower than world prices. Under the current National Energy Policy the price of oil in Canada is scheduled to rise, in stages, to a maximum of 75 percent of the world price equivalent in Montreal by 1984.

There are no direct Federal taxes on coal. Coal, as a natural resource, is a Provincial responsibility and each province sets its own policy with regard to royalties, depletion allowances, etc.

3.0 TAX INCENTIVE FOR CLM CONVERSION

There are, at present, no special tax incentives for CLM conversion.

A.5 FINANCIAL DATA AND COST DATA FOR ECONOMIC ANALYSIS

1.0 FUEL COSTS

1.1 Delivered oil cost (1981) = $18.19/bb (at Montreal)

1.2 Estimated oil costs for 1982-1990 = (1982) $25.08/bb (at Montreal)
(1983) $31.52/bb
(1984) $39.73/bb
(1985) $47.93/bb
(1986) $56.15/bb
(1987) $64.39/bb
(1988) $72.65/bb
(1989) $80.94/bb
(1990) $89.26/bb

Comments:

The above oil costs are based on Alberta conventional old oil prices as established in the Alberta-Ottawa Agreement in 1981, plus $1.58/bb transportation cost to Montreal. Transportation costs have been increased according to the inflation rates quoted in Section 2.0 below. Oil prices are subject to uncertainties of world oil prices and possible changes in Canadian energy policies.

1.3 Delivered coal cost (1981) = $2.02/$10^6$ Btu (Halifax)
= $0.43/$10^6$ Btu (Alberta minemouth)

1.4 Estimated coal costs for 1982-1990 = 8% increase per annum (compounded) over 1981 costs.

Comments:

Coal costs and quality vary widely in different parts of Canada.

2.0 INFLATION RATE

2.1 Estimated Inflation rate (1982): 12%

2.2 Estimated inflation rate (1983): 12%

(1984 - 1990) 10% high, 8% low

3.0 FINANCIAL ASSUMPTIONS

3.1 Debt/equity (for utility): Publicly owned 85-90/15-10%
Privately owned 50% debt/15% preferred/35% common
(for industrial): vary

TASK B:

DEVELOPMENT OF AN IEA CLM CO-OPERATIVE PLAN

3.2 Debt rate: Interest rate based on bond rating and mix of bonds, preferred and common stock.

3.3 Equity rate: Debt rate normally for publicly owned utility. For private utility return on equity is normally somewhat higher than average debt rate.

3.4 Tax rate for CLM conversion: N/A

3.5 Depreciation method: Straight line

3.6 Expected rate of return:
for public utility-interest coverage: 1.2-1.3;
for private utility and industry: varies (current range 15-20%)

3.7 Expected pay back period = under 5 years

4.0 CAPITAL COSTS

4.1 Capital costs for CLM preparation plants:

A future centralized CWM plant at Sydney, Nova Scotia (CBDC), at about 200 tonnes/hr. production rate, is planned to be installed at the following estimated costs:

- Coal handling and crushing	$ 4,380,000
- Grinding	5,690,000
- Flotation	3,500,000
- Dewatering	2,980,000
- Reagent preparation	890,000
- Building	3,950,000
- Electrical	3,500,000
- Laboratory	870,000
- Water supply	1,320,000
- Tailing dam	1,750,000
- Slurry storage tank	1,300,000
- Power and temporary costs	880,000
- Design and construction	3,930,000
Total CAN'82	$ 34,940,000

4.2 Capital costs for boiler conversion:

In connection with CWM program, a 150 MW-rated oil-fired boiler is planned to be converted to COM-firing at the following estimated costs

	(CAN.$'82)
- Burners and back-end modifications	$ 2,930,000
- Electro-static precipitator	$ 4,720,000
- Fly ash handling	$ 1,880,000

Subtotal	$ 9,530,000
- Engineering (20% of sub-total)	$ 1,910,000
Total	$11,440,000

Unit cost: $76.27/kW

5.0 OPERATION AND MAINTENANCE (O&M) COSTS

Not available

III. TASK B: DEVELOPMENT OF AN IEA CLM CO-OPERATIVE PLAN

B.1 TECHNOLOGY ASSESSMENT

1.0 PROJECT DESCRIPTION - PROJECT NO. 1

- Title: Demonstration of CWM Utilization

- Performer: New Brunswick Electric Power Commission (NBEPC) and Cape Breton Development Corporation (CBDC)/AB Carbogel (ABC)

- Funding: Energy, Mines and Resources Canada (EMR)

- Cost: $5.5 Million

- Schedule:
  - Phase I: September 81 - April 82
  - Phase II: May 82 - July 83
  - Phase III: August 82 - November 83

- Manager:
  - Phase I: M. Sroka, Montreal Engineering Company
  - Phases II & III: D.M. Rankin, NBEPC

- Objectives:

To determine the technical and economic feasibility of converting oil-designed thermal power boilers to operation on a low ash and sulphur 70:30 coal/water mixture based on Nova Scotia coal.

- Phase I: Planning, scheduling and budgeting
- Phase II: Burner development, construction of CWM pilot plant, and CWM combustion tests
- Phase III: Burner scale-up for 50-150 MWe boiler
- Initiation date: 14 September 81
- Current status:
  - RFP's issued for burner design, testing and manufacturing (NBEPC)
  - design of CWM pilot plant in progress (CBDC/ABC)

2.0 TECHNICAL DATA - PROJECT NO. 1

2.1 CWM preparation process:

Under licencing agreement between CBDC and AB Carbogel of Sweden (ABC), the latter company's proprietary preparation process will be used for preparation of CWM on a pilot plant scale of about 4 tonnes/hr capacity. The plant input will be CBDC washed metallurgical coal at about 3% ash and 1.5% sulphur and the plant output will be a stable and pumpable 70-75/30-25% (coal/water) slurry with the ash less than 2% and sulphur less than 1%. The coal is wet ground to very small particle size (ground to 80% minus 200 mesh) in order to allow for the physical separation of mineral matter and inorganic sulphur. The milling system is designed to achieve the optimum result when grinding coal to the required particle size. The

ground product is put through a physical separation process, where a coal concentrate is produced. Chemical additives are used to enhance yield and selectivity in the separation process. The coal concentrate is dewatered and additives are employed to yield a stable and pumpable slurry with optimum rheological properties.

2.3 Major Equipment

Phase II of the project includes develpment of safe, efficient and reliable burners for both front-wall and corner fired boilers designed for oil-firing. Some 200 tonnes of CWM will be used for the burner development work which includes assessment of existing and available burner designs, followed by design of suitable burners and in-house cold and hot testing. The minimum required burner nozzle life of such designed and tested burners will be 500 hrs. Phase II of the project also includes combustion tests on 12.5 MWe front wall-fired and 20 MWe corner-fired boiler configurations. Some 6000 tonnes of CWM in total is anticipated to be burned during the combustion tests, which will include boiler efficiency and flue gas composition measurements, establishment of derating levels and scope of furnace and boiler back-end modifications. Prior to the combustion tests only front-end boiler modifications will be performed.

2.5 Rheology

During development of burners, initial target CWM characteristics might be modified in order to achieve proper atomization and reduce erosion of burner nozzles to meet the target life.

2.7 Handling and Transportation

Production and transportation of 6000 tonnes of CWM needed for the combustion tests are purposely scheduled for winter months (Dec. 82 thru Feb. 83) with intention to evaluate this aspect of CWM technology under most severe environmental conditions.

1.0 PROJECT DESCRIPTION - PROJECT NO. 2

- Title: Beneficiation by Spherical Agglomeration for COWM fuels
- Performer: Technical University of Nova Scotia (TUNS), Halifax, N.S. (Coal Research Laboratory)
- Funding: National Research Council of Canada (NRC)
- Schedule: September 82 - September 83
- Cost: $25,550
- Manager: A.M. Al Taweel, TUNS
- Objectives: To obtain data on the effects of oil agglomeration cleaning on CWM stability, and to devise procedures to minimize adverse effects

2.0 TECHNICAL DATA - PROJECT NO. 2

The proven advantages of spherical agglomeration cleaning of coal for COM and COWM fuels may not be so readily realized in CWM preparation because of the unknown effect of oil carry-over by the coal on CWM slurry stability. This project will detail the effect, and devise treatments to minimize the impact of beneficiation by spherical agglomeration on CWM stability.

1.0 PROJECT DESCRIPTION - PROJECT NO. 3

- Title: Development of Stable, Pumpable Coal-Water Fuel Dispersions
- Performer: Technical University of Nova Scotia (TUNS), Halifax, N.S.
- Funding: National Research Council
- Schedule: April 1981 - March 1982
- Cost: $47,000
- Manager: A.M. Al Taweel, TUNS
- Objectives: To develop slurry stabilizing additives and document the rheological properties of the resulting CWM fuels.

2.0 Technical Data - Project No. 3

The work will address the evaluation of additives and select the most effective one within the time framework available for two types of low-ash coal. Slurry fuels prepared to the evolved specifications will be evaluated in terms of their rheological properties as determined in an instrumented pipe loop array. For further information, see "Rheological Properties of CWM and COW" by A.M. Al Taweel and al., Proceedings of the 4th International Symposium on Coal Slurry Combustion, May 1982, Orlando, Florida.

1.0 PROJECT DESCRIPTION - PROJECT NO. 4

- Title: Continuous Grinding of Coal for COM Fuel Preparation
- Performer: University of Toronto (U of T) and General Comminution Inc., Don Mills, Ontario
- Funding: EM & R
- Schedule: November 81 - December 82
- Cost: $140,000
- Manager: O. Trass, U of T
- Objectives: To obtain performance and design scale-up data for a commercial "SZEGO" mill
- Status: tests on 22 cm mill completed, tests on 44 cm mill near completion.

2.0 TECHNICAL DATA - PROJECT NO. 4

From the low rotational speed study systematic data on grinding kinetics have been obtained over a range of coal monosizes, slurry concentrations and mill designs. Good operation over a wide range of slurry concentrations, from thin slurries to thick pastes is possible with the Szego mill.

It may be concluded that the Szego mill is able to grind coal in oil down to very small sizes rapidly and efficiently. The resultant particle size distributions are relatively narrow. Following scale-up and further operating experience with the mill, it appears well suited for the preparation of coal slurry fuels.

For details on 22 cm mill see paper "Grinding of Coal-Oil Slurries with the Szego Mill - Effects of Solids Concentrations" by O. Trass, V.R. Koka, et.al. at the Fourth International Symposium on Coal Slurry Combustion, May 10-12, 1982, Orlando, Florida.

1.0 PROJECT DESCRIPTION - PROJECT NO. 5

- Title: Evaluation of Burner Erosion during COM Combustion

- Performer: Ontario Research Foundation (ORF)

- Funding: EM & R

- Schedule: March 81 - December 81

- Cost: $150,000

- Manager: A.S. Deshpande, ORF

- Objectives:

  The objective of this research program was to develop a data base on wear characteristics of fuel delivery and atomizing systems of existing generation industrial burners during extended combustion tests, using coal/oil slurries containing up to 40% w.w. beneficiated Prince Mine coal. In addition, important parameters associated with the combustion process were evaluted:

- Status: completed

2.0 TECHNICAL DATA - PROJECT NO. 5

During two 300-hour test period the following were evaluated:

- Combustion variables: including CO, CO_2 and O_2 on a continuous basis

- Boiler parameters: including temperatures, pressures and water flowrate on an hourly basis

- Flame characteristics: including stability, colour and concentricity at half-hour intervals

- Boiler efficiency at 12-hour intervals using the input/output methods in accordance with ASME, PTC 4.1

- Wear evaluation of burner fuel tips at 50-hour intervals as described earlier

- Fuel delivery variables: including pressure and temperature at one-hour intervals. Coal/oil slurry fuel flowrate was determined on a weight basis at nominally 50-hour intervals

- Flyash collection and analyses for combustibles at each one hundred-hour test interval

- Exhaust stack variables: including particulates, NO_x and SO_2 at the end of the 300-hour test

- Deposits: at the end of each 300-hour test the boiler was inspected and fouling was assessed.

For details see paper "Coal/Oil Slurry Combustion and Tribology" by L. Bruno, A.S. Deshpande and H. Whaley, presented at 4th International Symposium on Coal Slurry Combustion May 82, Orlando, Florida.

1.0 PROJECT DESCRIPTION - PROJECT NO. 6

- Title: Survey and Evaluation of Burner Designs for CLM Combustion

- Performer: Centre for Energy Studies (CES) TUNS, Halifax, N.S.

- Funding: CANMET/EM & R

- Cost: - Phase I: $11,000

  - Phase II: $20,000

- Schedule: - Phase I: August 81 - February 82
  - Phase II: July 82 - December 82

- Manager: - Phase I: G. Trivett, CES
  - Phase II: Grossman Enterprises

- Objectives:

  To compile data on the design and materials of construction of proprietary burners used with, or having the potential for use with, coal liquid mixtures.

- Status: Phase I completed.

2.0 Technical Data - Project No. 6

To the extent possible, complete data on burners used for CLM firing, or having the potential for such use, will be gathered from all world sources. Data will display design; materials specification; burner ratings and availability; and performance, if known, with CLM fuels. The data will be evaluated, paying particular attention to the scope for the substitution of more erosion resistant materials, and a short list of burners will be recommended for further testing.

1.0 PROJECT DESCRIPTION - PROJECT NO. 7

- Title: The Factors Affecting the Abradability of CLM

- Performer: TUNS for COW and R & PC (Research and Productivity Council of New Brunswick) for CWM

- Funding: EM & R

- Cost: - Phase I: 30,000
  - Phase II: 40,000

- Schedule: - Phase I: December 81 - May 82
  - Phase II: May 82 - May 83

- Manager: - A.M. Al Taweel

- Objectives:

To develop a procedure for measuring the ability of slurries to erode materials, and identify those slurry characteristics controlling abradability

Phase I:

Abradability test development will detail a procedure for obtaining an index of the power of a given CLM to erode materials. The test itself will then be used to quantify the slurry degradation that occurs during recirculatory pumping. Given data on the reduction of abradability with re-cycling time, burner erosion tests using pumped fuel may be designed to simulate burn tests with raw fuel.

Phase II:

The effect of particle size distribution, shape, coal type, ash content, water content etc. on slurry erosion of materials may be detailed.

- Status: Phase I (COW) completed

2.0 TECHNICAL DATA - PROJECT NO. 7

Conclusions, Phase I (COW):

To reduce the erosion in components handling CLM, it is recommended to:

- avoid high velocity streams impinging on solid surfaces

- reduce the amount of large-sized particles that have difficulty following variation in stream velocity and/or direction

- reduce the concentration of hard coal constituents (such as quartz and pyrite) during the CLM preparation stage.

Experimental findings indicate that COW could be recirculated up to at least 15 times while yield erosion rates, within 5 minutes, that are within ±5%.

For further details see "Erosion in Coal/Liquid/Mixtures Handling Systems" by A.M. Al Taweed, G. Murphy and I.D. Covill, presented at 4th International Symposium on Coal Slurry Combustion, May 1982, Orlando, Florida.

1.0 PROJECT DESCRIPTION - PROJECT NO. 8

- Title: Combustion Characteristics of Scotia Liquicoal Fuel

- Performer: Canadian Combustion Research Laboratory (CCRL)/CANMET/EMR

- Funding: CANMET/EMR

- Cost: N/A (in-house testing)

- Schedule: September 82 - March 82

- Manager: Dr. H. Whaley, CANMET

- Objectives:

  To determine the flame characteristics of a commercial COWM fuel.

2.0 TECHNICAL DATA - PROJECT NO. 8

Standard flame tunnel test methodology at a firing rate of 2.5 GJ/hr. will be employed on COWM (55% coal 12% water 33% No. 6 oil) to establish flame characteristics using a commercial external tip mix burner.

1.0 PROJECT DESCRIPTION - PROJECT NO. 9

- Title: Long-term Test Firing of Scotia Liquicoal Fuel

- Performer: Not yet determined.

- Funding:

- Cost:

- Schedule:

- Manager:

- Objectives:

  To demonstrate the availability of fuel production and fuel burner systems for commercial COWM.

2.0 TECHNICAL DATA - PROJECT NO. 9

Scotia Liquicoal will operate a pilot production plant having two lines, each capable of producing 1.5 tons per hour coal-oil mixture fuel (55% coal 12% water 33% No. 2 oil). Coal will be from a Nova Scotia source, beneficiated to 7% ash and 1.8% S. Pilot boiler trials have been completed; extended (200 to 500 hour) tests are underway to test burner performance; and the final phase, a 4 month continuous test on a 15 MW boiler, will complete the project.

1.0 PROJECT DESCRIPTION - PROJECT NO. 10

- Title: Combustion Characteristics of CWM
- Performer: CCRL/CANMET/EMR
- Funding: CANMET/EMR
- Cost: N/A (in-house testing)
- Schedule: September 82 - April 83
- Manager: Dr. H. Whaley, CANMET
- Objective:

  To determine the flame characteristics of commercial C/W slurry in relation to No. 6 fuel oil

2.0 TECHNICAL DATA - PROJECT NO. 10

The prepared fuel will be fired in a 2.5 GJ/h calorimetric flame tunnel in order to assist designers with basic combustion and environmental information necessary for the CWM program in utility and industrial boilers, kilns and process combustors.

1.0 PROJECT DESCRIPTION - PROJECT NO. 11

- Title: The Potential Derating of Utility Boilers due to CWM-firing

- Performer: - Front wall-fired boiler: B & W

  - Corner-fired boiler: to be determined

- Funding: CANMET/EMR

- Cost: - Front wall-fired: $50,000
  - Corner-fired: $50,000

- Schedule: April 82 - December 82

- Manager: Dr. H. Whaley, CANMET

- Objectives:

  To assess the derating of three sizes, two typical configurations of utility boilers on C/W fuel

2.0 TECHNICAL DATA - PROJECT NO. 11

Front wall and corner fired oil designed boilers are expected to be derated when utilizing C/W fuel. In order to support the C/W demonstration initiatives, information is to be generated by the boiler designers to assess the magnitude of this problem. A typical C/W slurry to be used in the program will be used as the reference fuel.

1.0 PROJECT DESCRIPTION - PROJECT NO. 12

- Title: The Production of Nozzle Materials by the Slip-casting Method

- Performer: Nova Scotia Research Foundation

- Funding: CANMET/EMR

- Cost: $15,000

- Schedule: October 81 - March 82

- Manager: Dr. S. Whiteway

- Objectives:

  To assess production techniques and test CLM nozzles made from slip cast Al_2O_3.

- Status: Work completed, the report is being prepared.

2.0 TECHNICAL DATA - PROJECT NO. 12

Nozzles were fabricated by slip casting and machined. The nozzles were then tested in a standard erosion test facility located at the Nova Scotia Research Foundation.

1.0 PROJECT DESCRIPTION - PROJECT NO. 13

- Title: Pumping Characteristics of COW

- Performer: TUNS Coal Research Lab, Halifax, N.S.

- Funding: Scotia Liquicoal Ltd.

- Cost: -

- Schedule: November 80 - February 81

- Manager: A.M. Al Taweel

- Objectives:

  To obtain performance data on the characteristics and intermediate-term erosion susceptibility of pump, control valves and piping systems used in handling COW.

2.0 TECHNICAL DATA - PROJECT NO. 13

COW produced from BROGEN and DEVCO coals were found to exhibit high sedimentation stability and are reasonably resistant to component segregation upon recirculation. Performance of two pump types (Moyno and Viking) was compared and minimal erosion was observed ater 100 hrs of operation. Characteristics of heat exchangers and pinch valve used in COW operation are similarly reported.

1.0 PROJECT DESCRIPTION - PROJECT NO. 14

- Title: Multi-Stage Flotation Column for Cleaning of Fine Coal

- Performer: TUNS Coal Research Lab., Halifax, N.S.

- Funding: EMR

- Cost: Phase I - $12,000
  Phase II - --

- Schedule: Phase I - April 81 to March 82
  Phase II - ---

- Manager: A.M. Al Taweel

- Objectives:

  To develop and test the performance of multi-stage flotation columns used in the beneficiation of fine coal.

2.0 TECHNICAL DATA - PROJECT NO. 14

Manufacture of CLM necessitates the fine grinding of coal and offers the potential of removing the mineral matter thus liberated. The fine size of the coal, however, adversely affects the performance of conventional flotation machines. A multi-stage column could achieve good de-ashing, while still retaining high coal recoveries. A prototype column was constructed and its hydrodynamic properties investigated. Preliminary trials with coals are promising.

1.0 PROJECT DESCRIPTION - PROJECT NO. 15

- Title: Performance tests on COWM in a firetube boiler
- Performer: Acurex Corp. California
- Funding: Canada-Nova Scotia Oil Import Substitution Agreement
- Cost:
- Schedule: November 80 - February 81
- Manager: Scotia Liquicoal Limited
- Objectives:

  Evaluate the combustion performance of COWM, including thermal efficiency measurements, emission measurements, and observation of any potential slagging, and fouling problems.

  Evaluate pumping and handling characteristics of COWM by observing problems associated with pumping, flow rate control, and effect on burner tips.

2.0 TECHNICAL DATA - PROJECT NO. 15

The combustion tests were conducted with several different COWM fuels at half and full boiler loads. Before the start of the tests and between each COWM test, residual oil was burned to season the boiler and to allow comparison between COWM performance and residual oil performance.

The fuel (COWM) was prepared by Scotia Liquicoal Limited using a spherical agglomeration technique to reduce the ash and sulphur content of the coal. Laboratory analysis of the fuel was supplied to Acurex by Scotia Liquicoal Limited.

The COWM itself was pumpable and atomized at lower temperature than the parent residual oil. The COWM could be pumped at 24°C and was atomized at a burner inlet temperature of 38 to 43.3°C. There were some problems with maintaining a constant flowrate. These difficulties were attributed to the fuel transfer pump and fuel filteration systems. For further details see "Liquicoal Demonstration Project", Third International Symposium on Coal-Oil Mixture Combustion, Orlando, Florida, Aug. 1-3, 1981.

One of the gear pumps (Viking) had to be replaced because of wear. The burner tip (Monarch) showed wear after 6 hours of use and was replaced before each test series; there were also problems with the strainer plugging and plugging in the burner itself. There seemed to be an upper temperature limit at which the pump could handle the COWM but this may be related to the amount of pump wear.

The boiler thermal efficiency was calculated using the heat loss method for the Phase II tests. These values were calculated using data which are averaged. The efficiency of the boiler when firing COWM was close to that achieved when firing residual oil.

Emission measurements for the Phase II values were carried out by Envirocon Ltd. (Toronto) and have been corrected to ppm at 3 percent O_2. Acurex as part of a U.S. Environmental Protection Agency project also performed some emission measurements during the Phase II tests. Most of this data has not yet been published, but the NO_x measurements are close to Envirocon's except for possibly test 5 where Acurex shows a higher value.

3.0 COAL BENEFICIATION

Canadian CLM program relates to development of COM utilizing NRC (Canada) oil agglomeration beneficiation process and development of CWM using Carbogel process.

Note: To comply with the Guidelines' sequence of numbering, the following two topics use the same reference numbers.

3.1 Oil Agglomeration Process

3.1.1 Process Description

Run-of-mine coal is first dry pulverized to 80 percent minus 200 mesh and collected into a water slurry by means of a dry cyclone, wet scrubber and mixing system. A wet attrition mill is then used for further size reduction to liberate impurities to produce ash contents of 10 per cent or less in the final recovered agglomerates.

The aqueous coal slurry is then pumped to the agglomeration system. Two agglomeration stages are used to take advantage of the superior de-ashing obtained with No. 2 fuel oil, compared with No. 6 fuel oil. In the first two agglomeration tanks, No. 2 fuel oil is injected into the impellers of the recirculating pumps to form small agglomerates which are then separated from the mineral matter retained in the water phase passing through a stationary inclined screen. Steps are being taken to minimize the requirement for No. 2 fuel oil by using emulsification with water.

The small agglomerates from this initial de-ashing step are then resuspended in hot (approximately 60°C) water in a turbine-agitated tank and mixed with heavy fuel oil (of the type normally used in the power station) to form larger (2 to 3 mm diameter) agglomerates. These agglomerates are sufficiently large, and contain essentially only surface moisture, so that when treated on a final vibrating screen, they dewater to 10 percent moisture or less. These agglomerates are then readily dispersible in heavy fuel oil to form the COM for combustion with controlled ash and water content.

3.1.2 Sulphur and Ash Removal Percentages.

On a pilot plant-scale (1 1/2 tonnes/hr) the following results were achieved using Cape Breton (Nova Scotia) deep mined run-of-the-mine coal as a feedstock:

	Coal	No. 6 Oil	No. 2 Oil	Water	COW
Ash (percent Wt)	9.1	0.05	0.005	—	2.2
Sulphur (percent Wt)	2.5	2.7	0.4	--	1.2
Percent Wt in COW	55.0	24.0	8.4	13	---
BTU/lb.	13,371				14,601

The cleaning process resulted in a reduction of ash in the final fuel of 76% and a reduction in sulphur content of 52%. In fact, the sulphur reduction is dramatic when it is considered that the sulphur in the oil was higher than the initial sulphur in the coal.

3.1.3 Currently the oil agglomeration process in connection with SLC activities has been operational on 1 1/2 tonnes/hr pilot plant scale and is being currently upgraded to 6 tonnes/hr scale.

3.1 Carbogel Process

3.1.1& 3.1.2 Carbogel process, ash and sulphur removal percentages are described in section B.1-2.1 in connection with CBDC/ABC/NBEPC coal-water activities. Physical separation of impurities, according to AB Carbogel, could be done by orthodox or new techniques. CBDC coals are very floatable, so it is expected that conventional flotation techniques would bring about desired purity of the product.

3.1.3 AB Carbogel has so far been producing CWM in a 10 tonnes/hr pilot plant in Sweden. 4 tonnes/hr pilot plant at Sydney, N.S., in collaboration with CBDC would be their first plant on the North American continent. Future plans are for 200 tonnes/hr commercial plant at Sydney.

3.2 Coal cleaning processes of the future are seen as evolution of the processes currently being utilized and developed.

B.2 INPUTS TO CLM COOPERATIVE PLAN

1.0 NATIONAL PROGRAM PLAN ON CLM

1.1 The government agency in charge of national CLM program is the Department of Energy, Mines and Resources (EM & R)

1.2 Summary of the CLM Program Objectives

Energy, Mines and Resources Canada has identified coal-liquid mixture technology development as a priority for funding under the National Energy Program (N.E.P.). Specifically these developments fall into three main areas:

.1 Coal/water slurry fuels for utility boiler applications

.2 Coal-liquid mixture fuels for industrial applications

.3 R and D support to CLM technology development

The Atlantic provinces of Canada, that is Newfoundland, Nova Scotia, Prince Edward Island and New Brunswick, are particularly dependent on off-shore oil. Therefore it is specifically to this region of eastern Canada that the Special Atlantic Initiatives Sub-program of the National Energy Program is addressed. The major objective of the sub-program is to assist the power utilities in the Maritime provinces to convert from fuel oil to alternative fuels wherever it proves to be feasible. The development of coal/water slurry fuels for utility boilers is being funded under the Special Atlantic Initiatives Sub-program and the technical and economic feasibility of converting utility boilers greater than 100 MW(e) to coal/water slurry fuels will be determined during the course of the next three years.

A similar initiative is being developed to apply CLM technology to industrial boilers. It must be noted here that COM's or any hybrid fuels containing fuel oil have generally been ruled out for utility application in Canada but this is not the case for industrial applications. This latter activity and the R and D support of CLM technology will not necessarily be restricted to the Maritime provinces under N.E.P. funding.

1.3 The Role of Government in the CLM Program.

1.3.1 Directly funded R & D projects: Most of the government-initiated projects fall into this category.

1.3.2 Cost-shared demonstration projects, in addition to being small in number, are also high in terms of government funding proportion.

2.0 CO-OPERATIVE RESEARCH PLANNING

2.1 Viewpoint of participant on R/D needs in CLM Technology (National Basis)

	More R/D is Planned	On-Going R/D is adequate	Commercial Status has been achieved
CLM Preparation Process		X	
CLM Combustion	X		
Major Equipment		X	
Instrumentation			
Rheology		X	
Environmental Controls	X		
Handling and Transportation			

Comments:

In the major equipment category only the burner is subjected to rigorous R/D program. Other equipment will be only evaluated on performance basis during burner and combustion tests. The latter also applies to instrumentation, handling and transportation.

2.2 Proposed Cooperative Research:

Based on preliminary discussions between CANMET (Canada), IRFF (Holland) and NEOM (Holland) it is proposed to conduct combustion tests with different CWM's and different burner types. These tests should as much as possible simulate the conditions within normal boilers, for which IRFF test facilities are specially suitable. The CWM selection should include:

- Carbogel process and Nova Scotia coal
- G & W process and a U.S. coal
- Slurrytech process and a U.S. coal. Reference test burns will be done on No. 6 residual oil and one of the U.S. coals (pulverized coal-fired). Comprehensive set of flame and heat transfer characteristics could be studied under controlled aerodynamic and combustion conditions. Opinions of participating IEA countries would be appreciated.

POOR

QUALITY

ORIGINAL